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DESIGNING AND IMPLEMENTING A LOW – COST INITIATIVE FOR REMOTE SURVEILLANCE TRANSMITTED OVER SATELLITE

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ABSTRACT

Surveillance is a very important aspect of security for a lot of organisations. Hence, there is a need to harness all available resources to cater for surveillance needs. The facilities available for surveillance till date is not sufficient to cater for remote facilities hence there is a need to develop a new model for surveillance, so as to be able to cater for remote facilities. Here, a new model is designed, which is the surveillance over satellite, to be able to cover remote areas with surveillance facilities. The surveillance system is unmanned and can be able to adequately cover the remote facility, at a low cost. The basis for the design is discussed and hence, the conceptual model developed. This was implemented using some of the available simulation tools like ADIsimPLL 3.1, Electronic Workbench 10 and ADIsim R.F 1.2. This is followed by the practical application of the surveillance system and an evaluation of the design is done, comparing it with the current trends in technology, like the CCTV.

KEYWORDS: Surveillance system, Communication Systems, satellite communications,

INTRODUCTION

Communication as a field of study has evolved over time, with continual discoveries of ground breaking technologies to cater for man's communication needs. This spans various areas from data, voice and video communication to communications for specific use. Applications in satellite communications have evolved over the years to adapt to competitive markets. Evolutionary development is a natural facet of the technology because satellite communication is extremely versatile. This is important to its extension to new applications yet to be fielded (Elbert, 1987).

Time and again, different hardware technologies have been implemented to cater for each of these needs, and on a regular and continuous basis, these technologies are reviewed and improved upon so as to proffer the best possible solutions to this needs and to also keep up with the pace of technological advancement. This is evident in the recent shift from analog communication systems to digital communication systems. When discussing digital modulation techniques, a recent study by Agilent Technologies reveal that "the move to digital modulation provides more information capacity, compatibility with digital data services, higher data security, better quality communications and quicker system availability" (Agilent Technologies, 2001). When talking about digital modulation, there are various techniques employed for digital modulation which include; Frequency Shift – Keying (FSK), Amplitude Shift – Keying (ASK), Phase Shift – Keying (PSK), Minimum Shift – Keying (MSK) and so on. In each of the above techniques, the phase, frequency or amplitude of the carrier signal is shifted and keyed. Also, for efficient modulation, many trade-offs must be made in selecting a particular technique, the trade-offs being defined by the communications environment, data integrity requirements, data latency requirements, user access, traffic loading, and other constraints. These new modulation techniques have been known in theory for many years, but have become feasible only because of recent advances in digital signal processing and microprocessor technologies. (Marvin, 2003)

Another challenge which has been reduced to a very minimal level in communications systems is the problem of noise. Noise is always present in every functional communication block (system), but the level to which it is reduced determines the performance of such system. In a communication device, the only noise that is under the designer's control is thermal and inter-modulation noise of the system. Assuming that the system is designed to minimize these, we do not have any way of reducing the noise (Langton, 2001). Also more often than not, analog systems have been very vulnerable to corruption of signals by noise. But with the advent of digital systems, noise has been properly clipped, using the appropriate hardware like filters and using veritable transmission techniques.

Recently, in satellite communications, PSK techniques have been discovered to be efficient for modulation and hence, it is used mostly in satellite communications and some CDMA telephones. PSK, compared with other schemes, has excellent protection against noise, because the information is contained within its phase (Kolawole, 2002).

Again, there is a wide variety of applications of satellite communications. This includes voice and video telephony; television signals transmission, fixed satellite service, mobile satellite technologies, direct broadcast satellites, amateur radio, IP over satellite, military communications and so on (Thomas et al., 2003; Monperrus, et al., 2008; SEVGI 2010).

The application of satellite communications is wide and varied, but there are still a lot of areas to explore, using satellite communications systems. Since satellite communications is basically reliant on the principles and properties of transmission and reception of RF signals, it can be applied to, practically, any aspect of communication be it digital or analog. This then stands to mean that we can harness satellite communication system in the design of communication systems for specific use.

Surveillance is a very important aspect of security and its importance cannot be undermined or overemphasized. This is evidenced by the huge losses that have accumulated for different countries over time, due to lack of a good surveillance infrastructure. Surveillance has also grown over the years from its analog to its digital form. Even beyond this is the more recent Closed-Circuit Television (CCTV) approach to surveillance.

In this paper we present a new model of a low-cost, security-aware satellite communication system. The model is based on the basic facts that digital signals can be more easily transmitted over the satellite than analog systems and that video signals can be compressed and transmitted over the satellite.

METHODOLOGY

Modelling and Simulation of the Surveillance System

The transmission of video signals is the underlying principle in surveillance, but there are other intricacies that must be considered in the design of the transmission and reception earth terminals to ensure that the surveillance system performs optimally.

There are some basic factors which affect the efficiency of a communication system. These are the transmission power of the signal, the bandwidth and the modulation technique employed for the modulation of baseband signals to RF for transmission (Nelson, 1998).There are also constraints that are peculiar to the design of the system and they include: Citing of communication facilities, Frequency band requirement for transmission; Availability of grid power supply to remote location; Cost of linkage to transmission satellite transponders; Effect of vandalism on the remote facility, The range of coverage of single cameras and Life span of the entire system. Hence there is always a need to balance the trade-off levels between the factors and the constraints (Nelson, 2001). Thus to achieve maximum efficiency, careful selection has been made of the hardware/components to be used. In a bid to balance the trade off between the factors that determine the effectiveness of the communication system channel and the constraints posed by the site of the remote facility, the following method was used:

An anomaly is expected to signal disruption of the normal activity of the remote facility. When an anormaly is detected in the vicinity of the remote facility, by a simple intrusion detection circuit, which can be a sound, fire, smoke, or motion detector circuit, a microcontroller unit receives a high logic from the detection circuit. The microcontroller will then triggers the entire system on. This unit is programmed to function as expected. As soon as the system comes on, a link is established with the network operating centre over the satellite and video is then collected from the cameras within that region, compressed and transmitted over satellite. At this point it should be noted that video signals can be transmitted over a long distance and through any transmission medium when transmitted in a digitized form and can be multiplexed with any other signal. Hence, the video signal from a PAL based surveillance CCD camera can be sampled and digitized based on the ITU-R BT656 standard. This can further be compressed using the MPEG-2, MPEG-4 or JPEG-2000 format. This compressed digital video can then be sent through any medium.

The video stream from all cameras, alongside any other signal, be it data or sound (voice) can then be multiplexed, modulated and sent over the satellite. To reduce the noise in the system, the signals are amplified and filtered. Once

transmitted, the incoming signal at the network operating centre wakes the system up and the streamed video is down converted, demodulated and decompressed into the original analog format. This is then further encoded into the format for delivery. At the network operating centre, the digital signal being sent is demultiplexed and the various streams from each of the cameras are viewed by an array of LCD screens.

The incoming signals can be manipulated and stored on a retrieval system for further use, while security personnel is informed about the detected anomaly.

The surveillance system was simulated and performance characteristics curves obtained. These curves measured the performance of individual components required for the implementation of the device and also, a cascaded analysis was carried out.

The simulation was done in two parts which included:
Simulation of variable response components' performance. This includes measuring the performance characteristics of each of the components and the working conditions of such system. This was carried out using simulation packages which included ADIsimPLL 3.1 and Electronic Workbench 10.

Simulation of the transmission and reception stages in the design to get the values for the output characteristics. The simulation package, used in this case is the ADIsimRF 1.2.

System Description
This model flow diagram is as shown in figure 1.

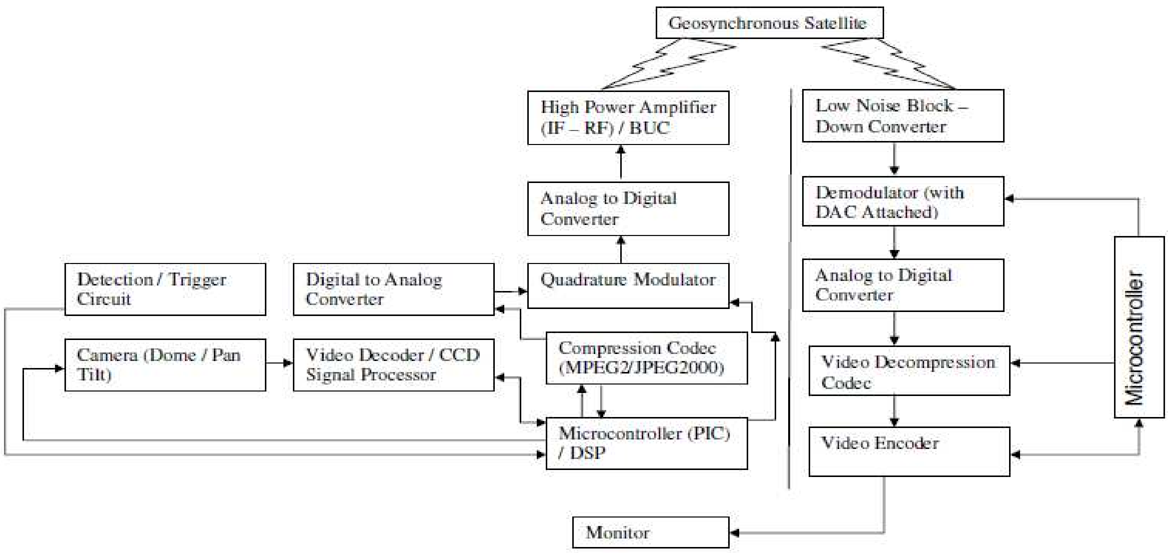

Fig. 1 Operational Flow Diagram for Surveillance over Satellite Model

From the model (Fig. 1), the surveillance system can be divided into four phases namely: the detection phase, which detects an anomaly and triggers the other components on; the video processing phase, where the analog (PAL) signal from the surveillance camera is processed and converted to a digital, compressed video; the transceiver phase, where the compressed video is modulated, up – converted, transmitted, received, down – converted and de – modulated and the last phase, which is the output phase. In the output phase, the signal undergoes decompression, and is converted back to the analog form for viewing or is sent to a video / digital signal processor for further processing before viewing.

RESULTS AND DISCUSSION

The Simulation Results

The results of simulating the video signal as would be produced from the modulator for up – conversion or for direct transmission through the satellite are shown in the graphs below.

Figure 2 shows that at a very low offset frequency, the single side band phase noise of the VCO is minimal and this produces a nearly perfect (noiseless) modulated signal from the system. But with the increase in offset frequency, the noise in the system increases considerably. An acceptable level for a typical synthesizer is about 60dBc/Hz; hence, the offset frequency of the VCO should be kept at around 1 KHz.

Figure 3 shows the phase noise value of the individual components and the total phase noise of the PLL / Synthesizer. Here, when the offset frequency is slightly above 100 Hz, the phase noise is lowest. Hence, this sets a threshold for the offset frequency for optimum performance.

Figure 4 gives the FM response for the amplitude and the phase. At a threshold offset frequency of 1 KHz, the modulation response is close to peak for both the amplitude and phase. The amplitude modulation response is about -12 dB with a phase margin of about 118^0. Also for the phase, the response is slightly above 0 dB with a phase margin of about 160^0. This means that for optimum performance of the synthesizer, the offset frequency should be kept around 1 KHz.

Hence from the above plots we can conclude that for the optimum performance of the digital synthesizer, as well as for the modulated signal to maintain its phase characteristics and reliability, the offset frequency should be maintained around 1 KHz.

From figure 5 it can be deduced that the chip will work more favourably, producing a greater output power under low temperature conditions but it can withstand temperatures as high as 85^0C, without dropping so much in output power. Figure 6 shows that low temperatures are favourable for the operation of the demodulator and, hence; the temperature of the system should be kept low for optimum functionality and performance. A suitable range of frequencies for optimum transmission is between 1 and 100 MHz, at a response level of about 0 dB. This is a near perfect response. The noise Vs RF frequency plot (Fig. 7) indicates that at a lower temperature, the noise figure is reduced to about 14.5 dB as against 17.5 dB when operating at a frequency of about 1720 MHz. This also shows that low temperatures favour optimum performance of the chip, and in general, the system.

Hence from the simulation of the modulator and the demodulator, we see the temperature of the system designed as a determining factor for optimum performance of the system.

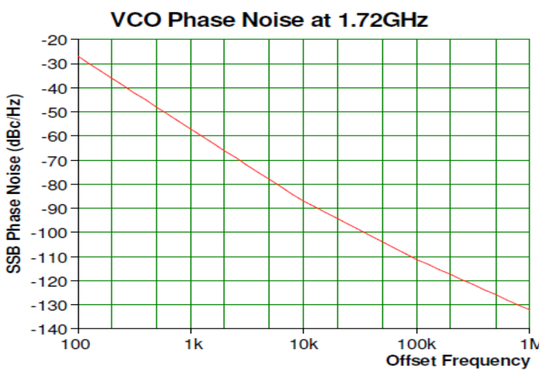

Fig. 2 Phase Noise Vs Frequency Plot for VCO

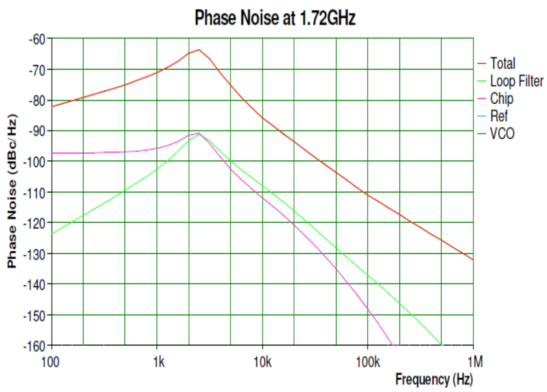

Fig. 3 Phase Noise Plot at output Frequency

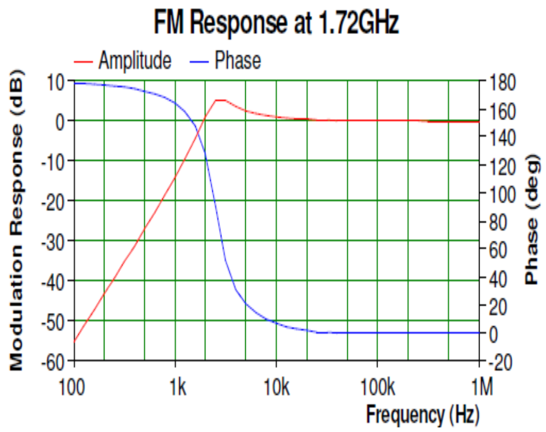

Fig. 4 Frequency Modulation Response at Output Frequency

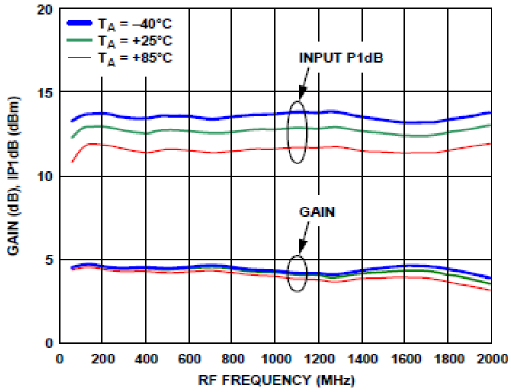

Fig. 5 Conversion Gain and Input 1 dB Compression Point (IP1dB) vs. RF Frequency

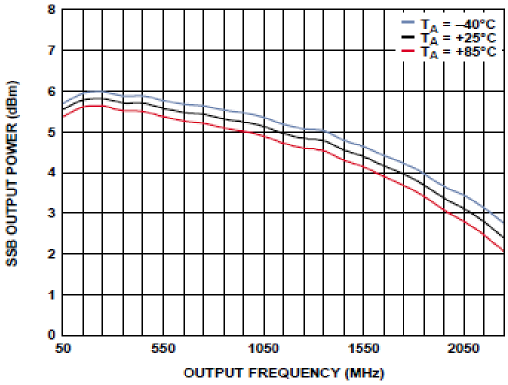

Fig.6 Single Sideband (SSB) Output Power (POUT) vs. Output Frequency and Temperature

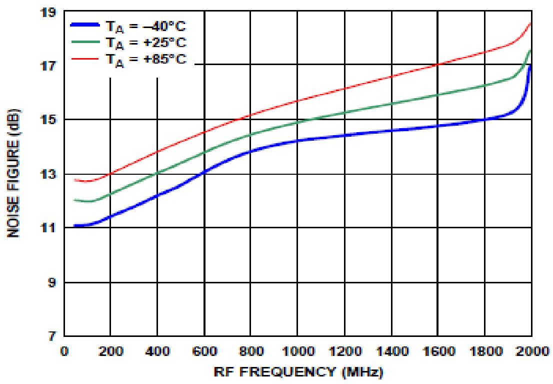

Fig. 7 Noise Figure vs. RF Frequency

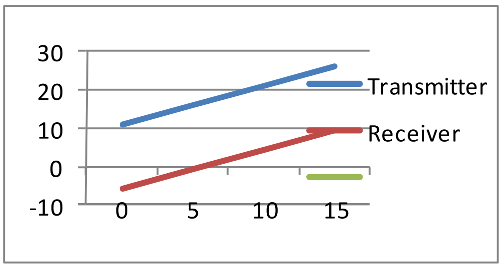

Fig. 8 Plot of Input Power Output power

System application
This system, which is referred to for short as “surveillance over satellite”, will be found useful in many areas including:
Monitoring of petroleum, petroleum products and gas pipelines

Monitoring of oil refineries

Monitoring of nuclear, gas and other power plants

Monitoring of water treatment plants for public use

Monitoring of power supply grids

Real time surveillance of assets

Tracking of goods and many more.

CONCLUSION
The surveillance over satellite model is based on the basic facts that digital signals can be more easily transmitted over the satellite than analog systems and that video signals can be compressed and transmitted over the satellite.

Evaluating the model design, two things can be deduced
There is a great deal of flexibility in the design. This is shown by the ease with which the components can be rearranged in the case of future upgrade to the system. Each of the components can be replaced also with another one should in case there is a need to change one of it. Hence the system is flexible. Another thing that accounts for flexibility is the fact that since virtually all the components used are based on the monolithic CMOS integrated circuit framework, then there is a little weight to grapple with.

The design helps achieve a low cost margin for the entire setup. Comparing the cost of designing and constructing this new model for surveillance over satellite and the cost of the previous methods of using DVRs, and other off the shelve finished products, the cost of the new model is about 30 % – 40 % less than the normal system for the old system. Hence, the model is able to achieve the low cost objective.

Comparing the above model with the conventional closed circuit television approach to surveillance, CCTV transmits via LAN and over the internet and is limited to areas which have access to internet facilities. Also to dedicate a VSAT internet facility to a remote facility solely for surveillance purposes will amount to a huge waste of the resources because of the cost of servicing both the ISP and the surveillance system, and in a case where fiber optics is used for the transmission, it becomes very expensive and these fiber optic cables can get damaged along the line. When this happens, it becomes very difficult to trace where the damage is and this cause a lot of problems finding it out.

Also CCTV cannot be effective over great distances for example between countries; hence, it becomes imperative to find another means to transmit the video data.

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